

## THE EPIDEMIOLOGY OF A DISAPPEARING DISEASE: MALARIA\*

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The honor of the invitation to deliver the 24th Charles Franklin Craig Lecture is greatly enhanced for me by the presence of Dr. Lewis W. Hackett, my first chief, as our presiding officer. It is significant that the invitation to speak on Malaria Eradication comes so soon after the masterly 22nd Charles Franklin Craig Lecture on "Malaria Eradication—Growth of the Concept and its Application" by Dr. Louis L. Williams, Jr., just 2 years ago. This reflects the interest of the American Society of Tropical Medicine and Hygiene in what has come to be the greatest public health effort of all times and the recognition by your leaders that the development of the program for the world-wide eradication of malaria is so rapid that this Society must have frequent reports, if it is to discharge properly the responsibilities assumed in 1951 when the American Society of Tropical Medicine and the National Malaria Society were fused to become the American Society of Tropical Medicine and Hygiene. This Society must be the voice of the tropical public health workers of the United States in all matters related to malaria. The responsibility of this Society is indeed great since the economic resources for supplies and equipment and for the technical and administrative training of national staffs essential to eradication programs simply are not available in many of the most malarious areas of the world. The continued and increasing support of the United States Government through multilateral and bilateral agencies is indispensable. The responsibility of this Society as a source of informed professional opinion will increase as the world program continues to develop and as obvious successes in many areas lead to a false sense of optimism with a natural tendency to relax and reduce the all-out effort before the goal is reached.

The unusual procedure of inviting a Charles

Franklin Craig Lecturer to speak on a specific subject followed, and may have been suggested by, the remarks made a few months ago for the Washington Tropical Diseases Association after a trip to Asia with Dr. Robert Briggs Watson of the Rockefeller Foundation. Our trip to Asia was to observe at first hand eradication programs which, after early dramatic declines in malaria incidence, had failed to reach eradication on the anticipated schedule. We visited Taiwan, the Philippines, Ceylon and Mysore State, India, before attending the Third Asian Malaria Conference (March, 1959) in New Delhi where personal contact was established with many malaria workers from Southeast Asia and the Western Pacific. Later I visited the eradication program in Thailand alone. These countries were carefully selected as those which had solved the bulk of their malaria problem but were facing the problem of final extirpation of the infection.

The impressions from this all too rapid visit may be summarized as follows: 1. In each of the countries visited the introduction of residual insecticides was followed by a rapid decrease in malaria, almost to eradication, in large heavily populated areas during the first 2 years of overall coverage. 2. No serious technical difficulties were encountered in any of the areas visited: anopheles resistance to DDT was not a problem, nor was extra-domiciliary transmission of malaria proven. 3. The administrative difficulty of getting full coverage with residual insecticide of all human habitations in all of the malarious areas, and the epidemiological difficulty of identifying areas where transmission continues, both contributed to the failure to eradicate malaria rapidly.

There has been a failure to develop proper supervision and checking of spraying operations and to adapt the techniques suitable for heavily populated, easily accessible populations to fringe populations, to nomadic populations, and to scattered populations living in hilly and forested areas. Particularly has there been a failure in certain instances to recognize the necessity for spraying temporary shelters used by rural populations in connection with seasonal crops. There has been a tendency to be satisfied with the

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general reduction of malaria, especially during the early years of the program, rather than to evaluate information from local communities to pinpoint places where malaria transmission continues. This blurring of the immediate objective of the eradication program, viz., the interruption of malaria transmission in each local community for the period required for spontaneous clearing of the infection in the human population, has led to costly delays, since partial eradication is always expensive.

In none of the countries visited had high blood indices persisted in the heavily populated, easily accessible areas, following the interruption of transmission. Nowhere was the charge of falsity made against the premise on which the eradication program is based. When properly used DDT had caused transmission to cease and malaria had disappeared rapidly.

The visits to the Asiatic eradication programs were entirely too short to do little more than gather general impressions from reading available reports, discussing details with program leaders and in some instances observing field operations. Surprisingly, each of the programs with minor variations seemed to fit the same pattern as outlined above. The analysis of the pattern indicates that the difficulties of malaria eradication are in general those of any eradication program and may be classed as, (1) administrative difficulties encountered in executing one hundred per cent of the necessary program, and (2) epidemiologic difficulties in identifying the places where the program has failed in its immediate objective and permitted transmission to continue. These difficulties seem to plague the health officer whenever he shifts from the concept of communicable disease control to eradication. The Public Health Administrator responsible for the control of communicable diseases, that is, reduction to the point where each disease is no longer a problem of public health importance in his community, tends to lose interest in the individual disease at the point where the eradicationist often encounters his greatest difficulty. This attitude is supported by international quarantine experience which shows that the threat of international movement of the infectious agents of communicable diseases is correlated with the epidemiological visibility of such diseases.‡ Also, the geographical area for

which the Public Health officer is responsible is generally small and the threat of peripheral reinfection great, so it matters little that the seeds of infection remain in his area. For the eradicationist, continuing unrecognized transmission below the threshold of visibility constitutes the greatest threat to victory in the battle for complete elimination of the sources of infection.

The communicable disease control officer can take satisfaction from the absence of reported cases and of public clamor, but the eradicationist can be happy only when he has proven that transmission has ceased.

To emphasize the need for special study of the manner in which a communicable disease continues near or below the threshold of visibility and of the measures for its final suppression, I proposed some years ago the term, "The Epidemiology of a Disappearing Disease." I was gratified to receive an immediate cash award from Dr. L. L. Williams, Jr., who recognized the value of the term for this concept in malaria eradication. Dr. Louis I. Dublin has since used the term, "The Epidemiology of Retreating Tuberculosis," and Dr. Luis Vargas the term, "The Epidemiology of Evanescent Malaria."

The situation of malaria eradication in certain countries of Asia at the present time bears considerable resemblance to that of yellow fever eradication in Brazil in 1930. Since this is a Society of Tropical Medicine and Hygiene, and since today we are considering impressions and general principles rather than detailed statistical information as to the progress of malaria eradication in specific countries, we may well digress on the problems of yellow fever eradication in Brazil 30 years ago and the measures taken for their solution. This digression is entirely fitting since here in Indianapolis 59 years ago this month Walter Reed made the first presentation of the work of the Army Yellow Fever Board (Walter Reed, James A. Carroll, A. Agramonte, and Jesse W. Lazear) before the American Public Health Association.§

areas can be declared free of any of these diseases when a period of only twice the incubation period of that disease has passed without the recognition of locally infected cases. This usage is based empirically on the observation that the chance of international movement of a given infection is relatively small when its incidence is so low that new cases do not come to the attention of the Public Health authorities.

§ Proceedings of the Twenty-eighth Annual Meeting of the American Public Health Association, Indianapolis, Indiana, Oct. 22-26, 1900.

‡ Present day international sanitary regulations provide, in the case of smallpox, relapsing fever, cholera, typhus, and plague, that local infected

By 1915 it had been observed that anti-mosquito measures in the important endemic centers of yellow fever in the Caribbean, Gulf and South American regions resulted routinely in the disappearance of yellow fever within a short period of time, not only in the endemic centers worked, but also in large tributary areas. General Gorgas logically concluded, and succeeded in convincing Wickliffe Rose of the International Health Commission of the Rockefeller Foundation, that anti-mosquito measures in the large cities of the remaining endemic areas of the Americas and of Africa would lead to the complete disappearance of yellow fever in the world. The initial efforts of the Rockefeller Foundation, collaborating with the health authorities of endemic countries of the Americas, were followed by the apparent disappearance of yellow fever from the west coast of South America, from Central America and Mexico, and from Columbia, and by 1925 the program for the eradication of yellow fever in Brazil, believed to be its last stronghold in the Western Hemisphere, was so far advanced that part of the Foundation's yellow fever staff was deployed to Africa to scout out the situation on that continent.

But yellow fever had not disappeared from Brazil, but had rather made a temporary tactical retreat in the face of the concerted onslaught in the large coastal cities of that country. Looking back from the vantage point of today this same pattern can be seen to have been repeated over and over again dating back to the first national eradication effort of the Brazilian Government. In 1916, General William C. Gorgas, as Chief of the Rockefeller Foundation's Yellow Fever Commission, had visited Brazil and been given evidence of continuing endemicity in the north-eastern states. The entrance of the United States into World War I early in 1917 prevented the return of Gorgas to Brazil and interrupted the program of the Rockefeller Foundation. In 1918 the Brazilian Government, without waiting for Foundation participation, undertook the eradication of yellow fever as a national project. The work of the Federal Yellow Fever Commission, 1919 to 1921, throughout the northern states was an outstanding accomplishment. Yellow fever retreated on all sides and disappeared from the statistics of the area worked and in 1920 the Brazilian authorities saw no reason for accepting Foundation collaboration which was then available. In 1921, with yellow fever no longer a problem, the Brazilian Yellow Fever Commission

became a rural health service with diversion of activity to hookworm disease, malaria, and other endemic conditions. In 1923, yellow fever reappeared and the Rockefeller Foundation undertook the organization of an eradication program in north Brazil. The rapid decline of yellow fever on all sides led once more to false optimism; a rude awakening came in 1926 when the movement of revolutionary and government troops through the interior led to widespread yellow fever outbreaks. Intensification of anti-mosquito measures over large areas followed and once more yellow fever receded precipitously from the statistics of the endemic area. In 1927-1928, a period of a year passed in which yellow fever was not recognized any place in the Americas. The re-infection of Rio de Janeiro, Brazil's beautiful capital, in 1928 from some unrecognized focus of infection, was followed by the widespread appearance of yellow fever along the coast from Rio to the Amazon Valley.

Anti-mosquito measures in Rio and the reorganization and intensification of such measures elsewhere led once more to the recession of yellow fever; but at long last it had become apparent that the premise on which the Rockefeller Foundation had embarked on the eradication of yellow fever was no longer tenable. It was obvious that the virus of yellow fever persisted unrecognized in spite of repeated anti-aegypti campaigns in all known endemic centers.

For almost three decades, *Aedes aegypti* had been accepted as the one and only vector of yellow fever; apparent confirmation of the monopoly of transmission by aegypti had come repeatedly from the regularity of the disappearance of yellow fever from the health statistics of endemic and epidemic centers after the breeding index of this mosquito was brought below five per cent.

The first reaction following the appearance of yellow fever in Rio in 1928 was to attribute the persistence of yellow fever to administrative failures in the northern endemic foci. The maintenance of top efficiency in anti-aegypti work over long periods is a notoriously difficult administrative problem and gross imperfections were known to have occurred. Support for the suggestion that administrative failure might be responsible for failure to eradicate yellow fever came early in 1929 with the finding of yellow fever within 200 meters of the headquarters of the Yellow Fever Service in Recife, Brazil, when the reported aegypti-breeding index was only eight-

tenths of one per cent, far below the accepted safe threshold of five per cent. A check sample of 100 houses scattered at ten different points throughout the city gave an overall aegypti-index of twenty-six per cent; the percentage of houses with pupal foci, that is with foci actually producing adult aegypti-mosquitoes, was eight per cent. This result clearly indicated that the administration of the anti-mosquito work in Recife was inadequate and raised the question as to whether or not yellow fever had been able to maintain itself in the endemic centers themselves, where its vector had been under attack for a period of 5 or 6 years.

Beginning in 1930 the anti-aegypti services were completely reorganized and uniform operating procedures established throughout Brazil with adequate provision for checking, rechecking, and double checking the work done; and with cross checking by determining the results of anti-larval work on the density of adult aegypti, and the overall effect on the occurrence of yellow fever itself.

The most useful method of cross-checking the results of anti-aegypti work was found to be the search for adult mosquitoes in the houses of areas where low breeding indices were reported. The capture of adult mosquitoes, long a measure used by malariologists in a study of anopheline mosquitoes, had been largely abandoned by yellow fever workers because of the accessibility and ease of observation of larval breeding places in artificial water containers in and around human habitations. The capture of adult mosquitoes can be very misleading when the breeding index is high with an overlapping of distributional patterns from individual foci, but once the density of the species is really low the study of the distribution of adult mosquitoes, which can be caught in human habitations, tends to reveal often within a matter of a few meters where the guilty pupal focus lies.

The intensification and improvement of administrative procedures together with the introduction of the capture of adult mosquitoes for the discovery of hidden aegypti breeding resulted in 1933 in the complete disappearance or eradication of the *Aedes aegypti* mosquito from some of the principal cities of north Brazil. This, the first observation of aegypti eradication during more than 30 years following the initial work of Gorgas in Havana in 1901, was of the utmost significance:

(1) in the development of a rational long-term continental program against yellow fever; (2) as preparation for the eradication of *Anopheles gambiae* from Brazil and Egypt; and (3) in the acceptance of the concept of eradication in the prevention of communicable diseases.

A more fundamental cross check on the results of the work of the Yellow Fever Eradication Service than that provided by the search for adult aegypti was gotten through the systematic search for and diagnosis of unrecognized and unsuspected cases of yellow fever during silent inter-epidemic periods. Fortunately, the liver tissue of the victim of fatal yellow fever has microscopic changes by which the disease can be diagnosed; the search for yellow fever was based on the routine collection and examination of liver tissue throughout all possibly endemic areas, to which the name viscerotomy was given. Viscerotomy was to show that yellow fever had maintained itself in Brazil, not in one, but in two unrecognized forms, neither of which was related in any way to deficient administration of aegypti programs in the larger endemic centers. The first revelation of viscerotomy was of silent village and rural aegypti-transmitted endemic yellow fever in a large area of northeast Brazil in the hinterland just back from the coast where the Yellow Fever Service had been heavily engaged in combatting yellow fever in the port cities. This area was silent largely because the endemicity was so intense that the great majority of infections (and of fatal cases) were in children less than 5 years of age among whom mortality caused little comment. The discovery of this unsuspected endemic situation led to anti-aegypti measures in interior villages and even in strictly rural areas throughout several states of northeast Brazil. The last case of yellow fever diagnosed in this region occurred in August 1934; it is now 25 years since endemic, aegypti-transmitted yellow fever occurred in Brazil. Lowering the threshold of visibility of yellow fever in this area then led to the eradication of yellow fever just as lowering the threshold of visibility of aegypti-breeding led to the eradication of aegypti.

An even more surprising revelation of viscerotomy is the widespread distribution of yellow fever existing in the absence of the *Aedes aegypti* mosquito throughout immense forested regions where yellow fever had never been recognized, or had not been reported for a decade or more. This

jungle yellow fever, which does not depend for its maintenance on man as the mammalian host, is associated with monkeys and other forest primates and has been shown since 1932 to be either enzootic or epizootic in large areas of the Americas ranging from northern Argentina to Mexico.

With the discovery of jungle yellow fever which constitutes a permanent source of virus from which the cities and towns of the Americas could be reinfected, it was realized that the eradication of yellow fever had been from the beginning an impossibility. It was recognized early that the discovery that the *Aedes aegypti* mosquito could be eradicated, just at the time of the first finding of jungle yellow fever, was indeed fortuitous. The eradication of *aegypti* in Brazil's port cities was followed by its gradual but complete eradication from suburban villages and rural areas, and today there is a well advanced program for the complete eradication of the *aegypti* mosquito from the Western Hemisphere. Although the United States has not yet formally embarked on the eradication of *Aedes aegypti*, the final result is inevitable since as each country frees itself of *aegypti* the pressure becomes greater on those which have yet to join in the continental program which is of permanent advantage to all.

No new administrative, technical nor administrative methods were involved in uncovering rural endemic and jungle yellow fever and in eradicating endemic yellow fever and the *Aedes aegypti* mosquito. The improvement in administration involved the careful mapping of areas to be worked, the establishing of itineraries for working units, careful recording of all work at the time it was done, careful supervision and checking of work done, the standardization of operating procedures according to a written Manual of Operations, and the inculcation of the principle in all employees that they were responsible not only for doing their job, but also for getting the results expected from the doing of the job. The use of the capture of adult mosquitoes for the determination of continued breeding was not new, but had not been used for many years in yellow fever work. The identification through viscerotomy of places where yellow fever is present was developed 18 years after the diagnostic value of the liver lesion in yellow fever was established. Only the viscerotome was new; while it was an im-

portant factor in the success of viscerotomy its use was not indispensable to the method.

The malaria eradicationist today faces essentially the same problems that the yellow fever eradicationist did 30 years ago; how improve the administration to guarantee complete effective application of the chosen method of attack, and how identify, on a continuing basis and at a reasonable cost, the places where transmission occurs in spite of the attack? How determine the epidemiology of malaria when there has been such a great reduction in the incidence of the disease that cases are not being reported? And especially, how get these results economically? Given the essential identity of the malaria problem with that of yellow fever, it may not be amiss to outline briefly for the malariologist the way viscerotomy is organized in the Americas.

Viscerotomy was introduced when there was good reason to believe that there was no yellow fever in the large cities of Brazil; information was needed from rural areas, and eventually from the most isolated parts of the country. A consideration of the cost of maintaining full-time employees in hundreds, nay thousands of small communities in the interior, led from the beginning to the decision to appoint local representatives to collect liver tissue from indicated cases. The law provides that a burial permit, wherever a viscerotomist is located, must be approved by the viscerotomist before the body is interred. If it is ascertained that death has occurred in less than 11 days after onset of a febrile disease, the representative removes rapidly with a special instrument designed for the purpose (viscerotome) a small section of liver before approving burial. The viscerotomist receives a small fee for each specimen forwarded to the laboratory for diagnosis and a considerably larger one for the first one showing yellow fever lesions. He also receives a small fee for forwarding monthly the statistics from the local registrar which would otherwise not be available.

The results of viscerotomy have not been perfect; on the other hand the cost is not excessive and most of the information on the movement of yellow fever virus during the past three decades has come from this procedure. Viscerotomy does not pretend to the discovery of all cases of yellow fever since by its very nature, viscerotomy is limited to fatal cases. Rather viscerotomy identifies the place where yellow fever trans-

mission is present; of almost equal value is the negative evidence for the non-existence of yellow fever in certain large areas over a period of years. The information viscerotomy gives regarding jungle yellow fever often comes from the most isolated and difficult areas, where the cost of maintaining service employees would be inordinately high. The local representative has the advantage of being resident in the community and is there day after day, week after week, month after month. It is in just such areas as these that malaria eradicationists are now encountering their greatest difficulties.

Malaria eradication in various countries today seems to be following the pattern of endemic yellow fever eradication in Brazil from 1919 to 1934; in the face of an energetic frontal attack malaria disappears, recedes, evanesces, but remains to flare up and ridicule the eradicationist so soon as the attack is abandoned and eradication put to the critical test of the complete suppression of preventive measures. All too often the eradicationist is finding that the insecticidal work in some of his areas has been as poorly administered as had been the anti-aegypti work in Pernambuco in 1929 and that his epidemiological investigation has not shown him the silent malaria transmission that was continuing in his "jungle" areas. Without entering into details of anopheles resistance to insecticide and of plasmodial resistance to drugs, it can be said that the technical problems in malaria eradication would be much more easily solved were it possible to recognize every new infection at the time it occurs so that the failure to block transmission in each small delimited area, whether due to technical or administrative failure, could be denounced and corrected. The malariologist does not have any economical method of recognizing each new infection and may well have to settle, as did the Yellow Fever Service years ago, for the identification of the places where transmission is occurring.

Epidemiological evaluation as a check on the completeness of the interruption of transmission by early insecticidal spraying is hardly less significant than similar information in the terminal stages of the program when surveillance is taking over. Proper evaluation during the attack phase of eradication is essential to the decision to abandon spraying and begin surveillance; precipitate unjustified action can force a highly

expensive reorganization whereas continued spraying when no longer required is equally wasteful. The malariologist must decide on the method of evaluation best adapted to his area: 1) routine systematic collection of blood slides from fever cases by local resident representatives; 2) routine collection of blood slides from fever cases by house visits of service employees at frequent intervals; and 3) mass or sampling surveys of all or of certain groups of the population without regard to history of fever.

#### *Comments on Malaria Eradication in Certain Countries*

*Philippine Islands.* In the Philippines after some 4 years of widespread coverage with insecticidal sprays in areas with over 8 million people, field surveys were made (1957-1958) and interpreted to mean that no transmission had occurred during a 2 year period among some 5 million people living in previously malarious areas. Spraying was suppressed in 1958 in these areas. Surveillance was organized on the basis of house-to-house visits every 3 weeks with the examination of blood slides from all fever cases found and of persons reporting fever during the previous 3 weeks. The analysis of the findings at the end of 10 months led to the reorganization of spraying operations throughout much of the area where they had been suppressed. Most of the recrudescence of transmission found was attributed to the introduction of the infection in the "eradicated" areas from the sprayed areas where transmission had never been interrupted. Under Philippine conditions, it is apparent that it is not safe to discontinue spraying in one area until the areas from which it can be reinfected have also been cleared of infection.

*Ceylon.* Ceylon was one of the first countries in Asia to benefit from the introduction of DDT which has been widely used since the malaria epidemic of 1946-47. The government decided early in 1949 to attempt the complete eradication of malaria from the island and by 1954 considerable areas where transmission could not be found were removed from the spraying program. In many areas *Anopheles culicifacies* could no longer be found. During 1955 the search for fever cases in dispensaries was relied on to show where transmission was occurring; many of these dispensaries were themselves outside of the area of transmission. The search for fever cases in

dispensaries and the follow-up of these cases to identify the areas where transmission was occurring so that treatment and insecticide could be applied proved ineffective and in 1956-57 there was a considerable reinvasion of the "eradicated" area by malaria. In 1958 the spraying program was reorganized and today there is an intensified search for fever cases throughout the island and greater insistence on finding and spraying temporary shelters in the forest clearings. The success of the present program will depend on the seeking out and spraying of all human habitations rather than on finding every infected person and treating him and his contacts.

*Taiwan (Nationalist China).* Taiwan is another country in which DDT was introduced fairly early and from which excellent results have always been obtained. Here, although malaria disappeared in a large part of the heavily populated part of the island, the incidence of the disease did not continue to zero, as had been hoped for. An investigation of the situation in 1958 showed that transmission had ceased in the heavily populated agricultural parts of the island, but that in the hilly, mountainous areas with populations with scattered habitations of difficult access, transmission continued. Investigation showed that some of these areas had been poorly sprayed and some had been missed entirely in the general campaign on the island. Reorganization and intensification of the search for infective cases and of the spraying of isolated habitations have led to a month-by-month reduction in the number of cases found since September 1958 and it now appears that practically all of the transmission on Taiwan has been blocked and it can be anticipated that this country will become the first of the Asiatic countries to be able to declare the eradication of malaria.

*Thailand.* In Thailand the application of DDT has resulted in a rapid reduction of malaria and in the practical eradication of *Anopheles minimus* in much of the area covered by the spraying operations. Suppression of spraying has been possible in certain areas without the recurrence of malaria transmission. Impressive settlement of previously uninhabited areas has occurred. The program has, however, developed slowly with initial plans for protecting only the 13 or 14 million people living in the most malarious areas;

it is, however, believed that another 9 million of the population live in areas exposed to risk. There is evidence that difficulties similar to those encountered in preventing transmission among peripheral fringe populations in other countries exist in Thailand and will become apparent with the expansion of the program to the forested areas. In summary, the program in Thailand is not sufficiently advanced to permit an appraisal of the problems to be encountered in the terminal stages of eradication.

*India.* The decision to undertake the eradication of malaria in India marked the inclusion of the largest single malarious population in the world in the eradication program. Although it was initially anticipated that anti-malaria measures would be applied in areas populated by some 225 million persons, it is now admitted that measures must be taken throughout areas inhabited by another 170 million people where malaria is relatively a minor problem. Although there are some reports of anopheline resistance to dieldrin, DDT seems to be giving excellent results. The program now being developed to complete the spraying of the homes of some 390 million people during 1960 represents a tremendous effort in financing and in administration. No serious technical difficulties are anticipated; the very size of the effort and the necessity of coordinating the programs of State services and of covering rural, nomadic and itinerant populations would seem to be the chief obstacles in India.

My remarks on malaria to this point have been devoted to the disappearance of malaria from parts of Asia. The term world-wide malaria eradication implies nothing less than the disappearance of all forms of human plasmodia. This disappearance must be not only from the Americas, from Asia and the Pacific, but also from the USSR, Communist China, Outer Mongolia, North Korea, North Vietnam, East Germany and from Africa. Some workers have tended to discount the possibility of malaria eradication in Asia since little was known of what was being done in those countries not members of the United Nations. In general, it would seem that the communist countries, with a governmental interest in the productivity of their populations and with relatively tight controls over their peoples, may be expected to eradicate malaria as fast as or even faster than

the free world, especially since most of these countries are not tropical.

In the USSR, a deliberate attempt to eradicate malaria dates from 1952 following an observed reduction in malaria incidence of almost 80% in 2 years. In the USSR, in addition to the spraying of homes with insecticide, all cases are given free treatment, are registered and supervised for a 2-year period. Malaria cases reported since 1950 by years are: 1950, 781,000; 1951, 351,000; 1952, 183,000; 1953, 116,000; 1954, 73,000; 1955, 36,000; 1956, 13,015; 1957, 5,095; 1958, 2,504.

To quote "... the malaria rate in the Soviet Union has been brought to such a low level that the country is on the threshold of complete eradication of this infection... the presence of the high rate of malaria in other countries of the world, especially in the countries adjacent to ours, is of real concern to us. Introduction of malaria... is at present gaining importance and increasing significance in the final period of local eradication of malaria.\*\*... The USSR shares

|| Sergiev, P. G., Reshina, M. G., and Lysenko, A. Ya. Malaria as a world problem and progress in eradicating malaria in the USSR. *M. Parasitol. & Parasitic Dis.* (Ministry Health USSR), 28: 268-280 (1959).

\*\* This statement is highly significant. The lecturer has had the opportunity of observing the step by step development of the eradication of the yellow fever mosquito, *Aedes aegypti*, first from a number of the principal ports of Brazil, then the gradual peripheral spread of eradication to the suburbs, to the interior villages and even to the rural areas of northeast Brazil, to the Amazon Valley and eventually to the City of São Paulo and to the southern reaches of the country where urban yellow fever had never occurred but where the presence of the *aegypti* mosquito threatened eventual reinfestation of the eradicated areas. From Brazil's experience with reinfestations coming from her neighbors came the 1947 demand for continental eradication and Brazil's generous contributions in men and materials in carrying the program, through the auspices of the Pan American Sanitary Bureau, to other countries. Each of these in turn, as *aegypti* disappears from their territories, joins in the clamor for eradication in the territories of their neighbors.

As the global malaria eradication program advances, inevitably a residuum of malaria will be found in certain countries with low economic resources and inadequate administrative organizations, to whom the cost and difficulties of eradication may seem prohibitive. It is inevitable that more assistance will flow, if for no other reason as a matter of self-defense, from the more fortunate nations. As the number of nations without malaria increases, the demand to abolish malaria from all countries from which re-infection might come, will increase and there should be continually

this outlook as to the possibility and necessity for eradicating malaria throughout the world.

"The participation of the USSR in solving the malaria eradication problem in the world has not been limited solely to the framework of WHO. In 1955, The USSR Ministry of Public Health, at the request of the Government of the Democratic Republic of Viet-nam sent a group of Soviet malaria specialists to North Vietnam, where they worked for about three years... In 1956, a group of malaria specialists was sent to the Chinese People's Republic for the basic purpose of assisting in training local personnel. As a result of five months work... a considerable number of Chinese specialists were trained."

The optimism and firm intent of the USSR malaria workers are apparent in the declaration that:

"The absence of new local cases for the absolute majority of regions in the country must be attained in the second half semester of 1959, and for the Azerbaidzhan SSR and Yukutsk of the ASSR not later than 1960."

Incomplete reports for 1958 showed 107 cases of malaria imported into the USSR, of which no less than 101 came from China. With regard to China I can do no better than quote from Dr. Williams' paper:

"Nothing specific can be said at this time of anti-malaria activities in Communist China but those familiar with her malarious areas perceive no technical difficulties standing in the way. Transportation difficulties are obvious in the various south-west provinces where terrain is rugged. However, roads are not entirely impossible and the local mosquito is notoriously susceptible to DDT."

In Africa, malaria eradication has been planned and is being attempted in a number of the more temperate countries, but there has been a certain reluctance to undertake eradication under present conditions in Africa south of the Sahara and north of Southern Rhodesia. The low economic level, the high rate of transmission, the shortage of trained personnel and the difficulty of communications in many parts of this region, when taken together, make the problem a formidable one. In spite of reported difficulties and local failures in the past, recent developments suggest

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decreasing difficulty in getting staff and funds for the ultimate objective of final eradication from all countries.



there are no sound technical factors which will preclude success of any serious attempt to eradicate malaria when the time comes. A warning should be sounded against any attempt to eradicate malaria on a too limited basis in tropical Africa since reinfection from the periphery may be expected to be a more serious problem there than in other parts of the world. The creation of national independent governments throughout Africa may well create a demand for international participation in eradication programs for that continent much earlier than would have been the case had previous political conditions been maintained.

In the Americas, practically all of the malarious countries are engaged in the eradication effort. Serious difficulties with anopheline resistance to insecticides have been encountered in El Salvador and in Nicaragua and to lesser extent in other countries. Extra-domiciliary transmission seems to be a factor delaying eradication in certain areas of Venezuela, Costa Rica and possibly other countries. The great reaches of the Amazon Valley present a difficult problem in logistics; an attempt is being made to solve this problem with medicated table salt.

I have referred to my impression that the Malaria Eradication Program in many countries today is in a position similar to that of the Yellow Fever Eradication Program in South America 30 years ago. I believe it is not too much to anticipate that just as improvement in administration and in methods for rendering yellow fever and its vector visible resulted in a definite change in the situation for the better at that time, so may we anticipate that the next few years will see tremendous advances in the intensification and improvement of efforts for the eradication of malaria throughout the world. In India where the greatest reservoir of malaria infection has existed, one sees the development of a truly national effort and a national determination to eradicate malaria forever. One cannot fail to be impressed.

There are times when one can take heart from the perspective gained by attempting to look forward from a previous point in the calendar. May I quote for your consideration from a forward looking address of 15 years ago, the Presidential Address†† of 1945 for the National

Malaria Society, one of the parent bodies of this Society:

"We are frequently reminded of the possibility of eradicating malaria in the United States, now that it is at a low ebb. I feel this is an untenable concept as we do not yet know in sufficient detail just where and under what conditions the disease occurs, or will occur in its last natural habitat. Possibly malaria will be eliminated but I much prefer to entertain the hope that we will build malaria out in our future developments and that we will attempt to 'reduce' rather than 'eliminate' it in its existing natural setting . . . it is unwise . . . to put malaria control operations into practice unless the disease is causing a measurable economic loss and unless the cost is in a measure commensurate with the economic ability of the people to pay."

But even as the President of the National Malaria Society was speaking, the die had been cast, and the budget item approved for the extended Malaria Control Program which was to become in 1947 the National Malaria Eradication Program. And indeed in 1950 and 1951 the National Malaria Society took steps for its own dissolution, as no longer necessary.

The action of the XIII Pan American Sanitary Conference in 1950 in recommending national programs for the eradication of malaria throughout the Americas was apparently ahead of its time and little stir was created until after the action of the XIV Pan American Sanitary Conference in 1954. The decision of Mexico to undertake a national malaria eradication program led to support of this program by UNICEF and the action of the Joint UNICEF/WHO Health Policy Committee approving malaria eradication for joint effort of the two organizations. This was followed almost immediately by the action of VIII World Health Assembly declaring for a world-wide malaria eradication program. The action and reaction of the 1954-59 period have been explosive in character in comparison with the slow speed at which international activities usually develop.

In 1957 the Pan American Health Organization received generous contributions to its Malaria Eradication Special Account from the governments of the Dominican Republic, the United States and Venezuela. In the same year the WHO received a sizeable contribution from the United States and the International Cooperation Ad-

†† Johnson, Henry A. Malaria in the Post-War Era. *J. Nat. Malaria Soc.*, 5: 1-6 (1946).

ministration began to participate officially in malaria eradication with funds earmarked for the purpose by the United States Congress. The ICA is participating in malaria eradication in some two dozen countries, including India which has the world's largest population residing in malarious areas.

The governments of nations throughout the world have been most enthusiastic in girding themselves for the task of financing the internal costs of eradication; the difficulties have been related to trained professional staff and international funds to cover materials which must be imported.

The program for the eradication of malaria in the world has implications far beyond the economic, social, health, and cultural effects of this disease. Once the pattern has been set for international collaboration on a world-wide basis in the eradication of a single disease, it is obvious that the road is open for similar action on other human, animal, and plant diseases, and insect and plant pests. On October 22, 1959, the Secretary of Agriculture announced the eradication of vesicular exanthema of swine in the United States. Vesicular exanthema had been present for some 20 years in California in a known but local focus of infection, which suddenly and unexpectedly had an opportunity to spread, apparently on dining cars on inter-state railway trains some 7 or 8 years ago. At its peak, forty-three states were known to be infected and embargoes were placed on the importation of United States pork products by ten countries: Canada, the United Kingdom, Columbia, Venezuela, Austria, Belgium, Sweden, Barbados, Jamaica, and British Guiana. California is now free of the infection at the price of having infected the other forty-two states and at the price of a 7 year campaign waged by the Department of Agriculture in collaboration with the state governments. In making this announcement Secretary Benson did not announce a program of co-operation with the ten clean countries which embargoed pork from the United States to help rid the rest of the world of vesicular exanthema,

but might well have done so had malaria eradication been completed.

Recent success in the dramatic eradication of the "screw worm" from its eastern range of distribution in Florida and Georgia leads one to the question: "If Florida has no 'screw worm' can Texas be far behind?" Eradication of the screw worm in Florida was possible because of the isolation of the eastern focus from other countries by the Gulf of Mexico and the Atlantic Ocean. Texas is not in a similarly favorable position and eradication there would put the United States in a defensive position, *vis-à-vis* the infested areas of Mexico. As Mexico proceeds in its program for the eradication of the *Aedes aegypti* mosquito, the urban vector of yellow fever from its territory, it faces a similar problem along the border with the United States and in its contacts with gulf ports. Well may the representatives of agriculture and of health of the two countries hold a combined meeting and arrange broad collaboration in the solution of both problems.

It may be well to close this Charles Franklin Craig lecture by quoting the words of the Secretary of Health, Education, and Welfare, when on October 20, 1959 he presented at the annual meeting of the American Public Health Association, contributions of two and of three million dollars respectively to the Malaria Eradication Special Accounts of the Pan American and World Health Organizations:

"The cause to which this money will be applied is a triumphant one. Never until very recent times has man dared to talk of 'eradication.' In all war against disease we have moved from helplessness to treatment and thence to prevention and control. As we move toward the eradication of a disease from the face of the earth we stand on the threshold of total victory for man over one of his oldest and deadliest enemies."

But total victory over malaria can come only as there is total coverage of infected populations and as malaria is not permitted to become a Disappearing Disease before it has been eradicated.